December 2, 2020

Project No. 13213023.00

MEMORANDUM

TO: Jacob Schmidt and Randy Deardorff, P.G.

FROM: Bret Clements, P.E. (KS 22717), Christopher Woloszyn, E.I.T., Eric Peterson, P.E., Robert Gardner, P.E., and Michael McLaughlin, P.E. (VA 020671)

Eric Peterson 12/2/20

SUBJECT: Monroe Township Landfill Leachate Sewer Discharge

INTRODUCTION AND SUMMARY

The Monroe Township Landfill (Landfill) discharged its leachate to the public sewer for decades almost without incident or complaint. Before 2020, only one odor complaint was received; the cause of the complaint was a defective trap in a residential laundry tub that was quickly repaired by BFI Waste Systems of New Jersey, Inc. (BFI).

Recent Changes in Leachate Management

Discharges of leachate from the Landfill to the sewer system were temporarily replaced in late September with tanker trucks hauling leachate to Chester, Pennsylvania (75 miles one way) and to Little Ferry, New Jersey (50 miles one way) for treatment. Odor complaints from several homes necessitated the change:

- The most likely explanation for odors is that surges of leachate displaced sewer gases through plumbing traps in affected homes.
- The small concentrations of aromatics in the leachate might be a secondary factor, and might explain a more chemical-like (as opposed to a sewage-like) odor.

The change to hauling leachate by truck came during October and November, which are historically the months with the fewest gallons of leachate generated at the Landfill. See Figure 1. Relatively few trucks (up to eight per day) were needed to haul leachate in October and November. Generally, March has seen the highest volumes of leachate, by a factor of 3.5 to 4 compared to October/November volumes, which also would correspond to an increased number of trucks per day that would be needed to haul leachate to a wastewater treatment plant.

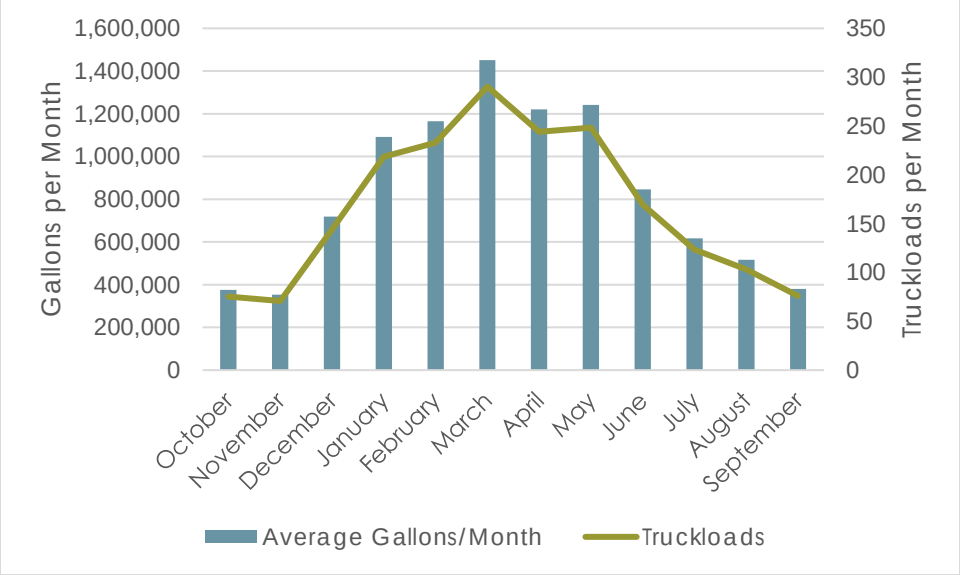


Figure 1. Average Monthly Leachate Production, 2013-2019

Pumps for leachate at the landfill previously operated at only one speed—leachate into the sewer was either full on at 80 gallons per minute (gpm) or full off. In the 10 weeks since discharges to the sewer were interrupted, BFI has improved the controls and motors on the primary pump to allow leachate to be discharged at different rates, depending on how much or how little sewage from homes already is in the sewer:

- If the sewer already is at or near peak sewage flows from homes, the leachate pumps will put little or no leachate into the sewer.
- When there is little or no sewage from homes in the sewer, more leachate can be pumped into it.

The goal of these changes is to keep the leachate underground storage tank (UST) at the landfill as close to empty as is practical (to reduce the potential for overfilling the UST), and to keep any changes in the liquid levels in the sewer gradual (to minimize displacement of sewer gases).

Leachate Characteristics Have Not Changed

In the first eight months of 2020, the landfill discharged 7.9 million gallons of leachate to the sewer. This is a little less (3% less) than the average amount of leachate discharged from the landfill in the January through August period since 2013—in other words, leachate is being produced in 2020 at about the same rate as the last seven years. Similarly, the chemical characteristics of the leachate have remained about the same over the last three years. Any odor problems in the sewer are not due to greater volumes of leachate or different contaminants being present.

The landfill generates 10 million gallons of leachate in the typical year. To carry that much leachate in 6,000-gallon tanker trucks would require 1,667 tanker truck trips each year. If each truck travels 100 miles round trip and trucks average 6 miles per gallon, that is about 28,000 gallons of fuel—and

more than 250 metric tons of carbon dioxide-equivalent greenhouse gases—every year, just to haul leachate. Discharging leachate directly to the sewer reduces the potential for accidents and spills, reduces truck traffic on neighborhood streets, and produces fewer greenhouse gases.

Schedule to Resume Discharge to Sewer

Resuming discharges of leachate to the sewer as soon as possible is important for the reasons summarized above, and because based on historical data the volume of leachate generated by the Landfill is expected to increase significantly between now and March (see Figure 1 above). Increases in leachate volume would require more truck traffic through the neighborhood if the temporary use of trucks to haul leachate was extended.

Since the changes to the leachate pumps and controls have been completed or are imminent, leachate discharge to the sewer can be safely resumed in a controlled manner. If problems are observed with use of the sewer, changes to pumping rates and schedules can be quickly implemented, and thus the system can be optimized over the next several weeks and months. Although not in BFI's control, we also recommend that the plumbing in those homes where odors were recently detected be checked regardless to confirm that the traps are functioning properly so that sewer gases do not enter the homes.

SITE HISTORY

The Landfill is a closed landfill owned by Monroe Township (Township), New Jersey. The Landfill was operated from 1955 to 1978, covering 86 acres before its closure. The Township operated the landfill until 1968 when it was leased to Princeton Disposal Service. In 1972, the company now known as BFI Waste Systems of New Jersey, Inc. (BFI), currently a subsidiary of Republic Services, Inc., acquired Princeton Disposal Services. BFI maintains the closed Landfill with onsite operations conducted by SCS Engineers and SCS Field Services (SCS) and other subcontractors.

In 1979 the state of New Jersey ordered the Landfill to undergo closure and required installation of a liquids collection system after leachate outbreaks occurred in 1978. The Landfill was placed on EPA's National Priorities List (NPL) in September 1983. It was removed from the list in February 1994. Since that time, the U.S. Environmental Protection Agency (EPA) has conducted five "Five Year Reviews." Five Year Reviews provide EPA an opportunity to evaluate the implementation and performance of a remedy to determine whether it remains protective of human health and the environment. The last review was conducted in 2019.

In the latest EPA review, under the Site Inspection, "No significant issues were identified during the inspection. All the engineering controls appeared intact and in good condition". Under the Protective Statement of the review, the EPA states "The remedy at the Monroe Township Landfill site is protective of human health and the environment". The Landfill has continued safe operations since its removal from the NPL in 1994. Prior to the summer of 2020, only one previous complaint of odor was reported to BFI. This particular complaint was related to a malfunctioning trap in a residential laundry room that, once repaired, eliminated the odors for the residence. Including the years prior to the removal from the NPL, the Landfill has maintained over 40 years of compliant operations.

ODOR EVENTS

Odor complaints in 2020 were first received by the Township on August 4, 2020. A series of emails from the Township and EPA led to an on-site meeting to observe the odors and to meet with residents. On August 13, 2020, SCS met with USEPA representatives John Osolin and Pat Seppi at the Landfill regarding odor complaints from local homeowners. Approximately nine homeowners attended the meeting with SCS and EPA. Intermittent odors were observed in early August. SCS and USEPA spoke with Monroe Township Utility Department's Robert Noel regarding flows and the history of the neighborhood.

Additional odor complaints were received at the Township's office in September. Residents observed odors on September 16 and 17. These events led to the Township's September 23 meeting with all involved parties to review Landfill operations and current conditions.

The Landfill continued its normal operation of discharging leachate into the sewer until the evening of September 23, when a final odor complaint was submitted to the Township after the meeting.

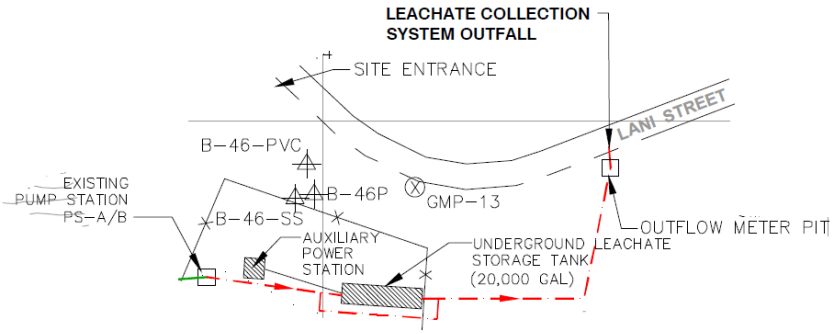
No leachate has entered into the sewer system since that evening. Starting on September 26, BFI contracted with a liquid waste hauler to transport leachate offsite to be disposed at a wastewater treatment facility.

Noticeable odors are believed to be limited to residences on Michelle Street and a house east of Michelle Street on Lori Street.

LANDFILL LIQUID CONTROL INFRASTRUCTURE

Under typical operations, the Landfill collects liquids through underground perforated piping and discharges them into the AB Sump. Liquids are pumped out of the AB Sump into the UST. From the UST, a level-controlled pump periodically pumps the liquids out of the tank and into a gravity sloped pipeline that drains through the flow meter. After passing through the flow meter the liquid discharges into the sanitary sewer system.

The Township has direct (remote) access to the data recorded by the flow meter.



SANITARY SEWER INFRASTRUCTURE

Downstream from the flow meter, liquids are discharged into the Township's sanitary sewer system. Liquids travel in an 8-inch pipe that gravity drains east along Lani Street. Several homes along Lani Street and Guinevere Road discharge into this sewer line. Ultimately, this line flows to a manhole

(MH-4) located at the intersection of Lani Street and Michelle Street. This manhole also collects liquids from homes along Launcelot Lane.

From MH-4 an 8-inch gravity sewer flows north under Michelle Street through additional manholes (MH-5 and MH-6). Homes on either side of Michelle discharge into this sewer line. Ultimately, this 8-inch pipe discharges into a manhole (MH-7) located at Lori Street and Michelle Street.

Because a number of residents along Michelle Street reported odors from the sewer, this section of the sewer system was the focus of analysis and inspection by SCS and the Township.

The sewer pipe beneath Michelle Street from MH-4 to MH-5 had the steepest slope of the pipes reviewed as part of this assessment, nearly 4%. The slope of the pipe from MH-5 to MH-6 was flatter at about 1% and from MH-6 to MH-7 became even flatter at about 0.5%.

Also of note is that at MH-5, the first manhole north of Michelle Street and Lani Street, there is a relatively steep slope of liquid within the manhole (the influent sewer pipe is above the bottom of the manhole). Both of these factors (steep slope feeding the manhole and steep slope within the manhole) likely create turbulent conditions. Turbulent flow can cause vaporization and atomization of volatile compounds, increasing the likelihood of odorous compounds escaping sewer liquids.

Once sewer liquids from Michelle Street are discharged into MH-7, the manhole at Michelle Street and Lori Street, the liquid is mixed with any liquids that are being conveyed by the sewer line that is serving Lori Street west of this manhole. The co-mingled sewage in this manhole is then discharged to an 8-inch pipe that drains the liquid east along Lori Street. The video inspection of this sewer,

conducted on October 13, revealed that there are multiple homes along Lori Street discharging into this line.

TIMELINE AND SUMMARY OF INVESTIGATION AND RESPONSE ACTIONS

Date	Investigation and/or Response Action
9/23/2020	Evaluated pump operations and discharge into sewer system; last day the Landfill discharged into public sewer system
9/26/2020	Landfill commenced use of tanker trucks to haul liquids to wastewater treatment plant.
10/1/2020	Public Meeting
10/8-9/2020	Cleaned AB Sump, Discharge lines from UST to sewer, the pipe from MH-12A to MH-13, and the pipe from MH-13 to AB Sump. This cleaning is required by the facility's permit.
10/13/2020	MTUD inspected select sewer lines along Lani and Lori Streets and all of Michelle Street.
	An evaluation of the sewer size has been provided in Attachment A. Attached to this memo are calculations showing that the sewer system is sufficiently sized to handle both the design residential sewer system loading event at diurnal peak flows plus the Landfill's liquids.

Date	Investigation and/or Response Action
10/19/2020	Collected Air and Liquid Samples at UST to try to identify cause of odor.
	The Landfill contracted with a toxicology specialists, Stantec, to evaluate its leachate and to try to identify components within the leachate that may be causing the chemical smell. Chemical smells are quite often associated with Volatile Organic Compounds (VOCs). VOCs get their name because of their ability to volatilize out of liquid and emit into the air.
	Stantec collected air and liquid samples at the underground storage tank (UST) which is the final location for leachate to be stored on-site prior to being discharged to piping which flows through the metering station. After the flow metering station the station then discharges the liquid into the sanitary sewer system at the termination manhole on Lani Street. See the Stantec report for results and additional information.
	In Summary and Conclusions of the Stantec Technical Memo, it is stated that the odors detected above American Industrial Hygiene Association odor thresholds could be consistent with the residents' complaints of "turpentine" or "acetone" odors..
10/22/2020	Made improvement to the storm water channel located outside the fence to clear the channel of trees and vegetation; old stone and vegetation were deposited on landfill; new stone was installed.
10/26-30/2020	Mowing and site maintenance were completed as required by the Site's Permit.
10/30/2020	MTUD provided a link to the sewer inspection video completed on October 13, 2020.
	The camera inspection revealed that the monitored pipes appear to be in working order as no significant damage was observed.
	The pipe along Lori Street did not appear to be receiving flows that exceeded approximately 50% of the pipe capacity as spider webs were observed in the upper half of the pipeline. Flows along Michelle Street appear to be at least periodically using more than 50% of the pipe's capacity. It is unclear what caused the flows within the sewer line to exceed the design flow levels. Flows in excess of the design levels may contribute to odors being emitted to homes.
	Installed the first of two 21,000 gallon tanks to provide additional capacity and flexibility in matching liquid generation and discharge to sewer.
11/3/2020	A variable frequency drive (VFD) was installed on the UST Pump motor.
	This improvement will allow the facility to adjust the rate at which the pump discharges leachate to the sewer system. Previously the pump would operate at maximum capacity anytime the pump was turned on. The VFD will also allow the site to gradually increase the pumping rate for each start up event, which will also reduce the potential for immediate pressurization to occur during pump startup events.
11/4/2020	UST was cleaned out, completing the cleaning from 10/9/20.

Date	Investigation and/or Response Action
11/5/2020	Additional liquid sampling occurred on-site.
	This additional sampling is being completed to try to identify the source of the potential odor causing compounds or determine if it was occurring near the UST.
11/6/2020	Gravel placement on site access road, expansion and grading.
	This will help aid in minimizing the amount of mud tracked onto the township's roads.
11/10/2020	Conducted first smoke test at resident's home.
	No smoke was found within the living area of the residence.
11/11/2020	Additional air and liquid sampling was completed at the UST
	Awaiting analysis of the results.
	Installed the second of two temporary 21,000-gallon tanks to provide additional capacity and flexibility in matching liquid generation and discharge to sewer.
Imminent	Facility will be upgrading the site's SCADA system for the discharge pump.
	This will allow the facility to program the pump system to discharge at specified rates at various time of the day if necessary.

NEXT STEPS

As summarized above, BFI evaluated several factors and completed response actions and upgrades to prepare to return to discharging liquids to the Township's sewer system, including retrofitting the Landfill's existing UST pump to be outfitted with a VFD and controlled by a SCADA system. These modifications will allow the Landfill to program the UST pump to discharge at the rate desired depending on the time of day and the diurnal flow pattern. The VFD will be set to gradually increase flow each time the pump turns on, rather than going from 0 gpm to approximately 80 gpm almost instantaneously.

Reducing the rate at which the site discharges liquids, during increased residential flow periods, will also have the beneficial result of reduced turbulence and reduced potential for leachate odors in the sewer. If the Township approves BFI's request to resume discharging leachate to the sewer during the Public Meeting on December 9th, the following steps are recommended:

Step 1

BFI will resume discharging liquids into the sewer as soon as December 10th per the plan below. The Landfill will begin reintroducing its liquids to the sewer system at the Week 1 rates shown in Table 2 of Attachment A, which will not exceed 45 gpm. In order to understand the flow dynamics within the sewer system, the Landfill will also temporarily deploy a device capable of monitoring flow conditions within the sewer system to watch for abnormal peak flows when the Landfill initially begins to discharge. In addition, a BFI

contractor will be onsite and in the neighborhood during the initial reintroduction of Landfill liquids into the sewer system to check for odors along Lani and Michelle Streets.

This modified discharge approach is different than previous operations because previously the Landfill would discharge flow in approximately 80 gpm surges followed by intervals of zero flow. The modified approach and schedule being proposed will reduce turbulence and mitigate the potential for volatilization of odorous compounds in the sewer.

Residents are encouraged to report odor observances to the Township where they can be relayed to the Landfill personnel. If odors are reported (either by BFI personnel or the neighbors), BFI will compare the time of the odor observance to the time intervals that the landfill was actually discharging liquids. If they appear to overlap then flow will be adjusted during that time period.

Step 2

Once the landfill has reestablished its leachate discharge to the sewer system and confirmed that no odors have been reported, controls will be modified to increase discharge rates to those shown in the table entitled "*Proposed Pumping Rates*". This change will provide the landfill operator with more latitude to avoid peak residential discharge periods. Avoiding discharging landfill leachate during peak residential discharge periods will aid in further reducing odors for residences. Also, please note that the Landfill will work with the community to adjust these discharge rates in an effort to reduce the likelihood of future odor observances by residences.

Step 3

Although not in BFI's control, we also recommend that concurrent with Step 1, the plumbing in those homes where odors were recently detected be checked to confirm that the traps are functioning properly so that sewer gases do not enter the homes.

ATTACHMENT A

SEWER SIZE EVALUATION

Table 1 shows the calculated capacity for the sanitary sewer system pipes filled to half their depth along Lani, Michelle and Lori Streets using the Manning Equation:

$$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$$

Where Q is the discharge, n is the Manning roughness coefficient, A is the cross-section area, R is the hydraulic radius, and S is the pipe slope.

As shown in Table 1 the capacity of half-full sewer pipes in the system range from a low of 184 gallons per minute (gpm) to a high of 529 gpm. The section with the lowest flow capacity will limit the flow through the sewer system; this is the pipe segment between MH-6 and MH-7 on Michelle Street.

To calculate how much the Landfill can discharge without exceeding the capacity of the sewer system, we must first calculate the expected residential loading of the sewer system. New Jersey Administrative Code (NJAC), Title 7 - Environmental Protection, Chapter 9A, Subchapter 7, Section 7.4, states that the criteria for estimating the volume of sanitary sewage from single residential occupancy activities shall be based on assuming 200 gallons per day (gpd) for the first bedroom and 150 gpd for each additional bedroom.

Residential listings along the contributing sewers include a number of 4 and 5 bedroom homes; therefore, to be conservative, we assumed all homes have 5 bedrooms and thus could contribute approximately 800 gpd for design purposes.

NJAC 7:14A-23.6 (Sanitary sewer design) requires gravity sewers to be designed to carry at least twice the average projected flow when flowing half full. This requirement recognizes that peak sewer flows occur when a neighborhood wakes up and takes a shower to start the day, or washes dinner dishes and takes baths at the end of the day. A number of studies have been performed to map this diurnal pattern. Table 2 is based on one such study;[1] it shows the diurnal flow pattern in half hour intervals to allocate the percentage of daily flow that is expected to occur during each half hour period. This Table shows that the highest percent of daily discharge from residential homes is expected in the 8:00 AM to 8:30 AM interval when 4.6% of the total daily flow is discharged. For a single home this works out to an average discharge rate of 1.23 gpm for this half an hour period.

As discussed above, the sewer pipe between MH-6 and MH-7 on Michelle Street is the most limiting section. Thirty-six homes contribute to this section and thus peak diurnal residential loading is expected to be 36 X 1.23 gpm = 44.2 gpm. In other words, even if this section of

[1] Gurung, T.R. Stewart, R.A. Sharma, A.K. Beal, C.D. (2014) Smart meters for enhanced water supply network modelling and infrastructure planning, Resources, Conservation and Recycling, 90, 34-50. http://dx.doi.org/10.1016/j.resconrec.2014.06.005.

sewer pipe contained 44.2 gpm (4.6% of the total daily flow from 36 houses), it still would have about 140 gpm of available capacity. As shown in Table 2, the Landfill is not proposing to exceed this 140 gpm at any point.

SEWER EVALUATION

After reviewing the video and profile information provided by the Township the following was inferred. Based upon residue observed on the upper portion of the sewer pipe along Michelle Street during the camera inspection, it appears that flows in the sewer pipe might have exceeded the design flow capacity of the sewer pipe. The cause of the residue observed on the ceiling is unknown; it may be due to the pipe being temporarily or partially blocked or to abnormally high flows. Either cause would increase the likelihood of odors being emitted from a sewer system.

The evaluation of the sewer system did not conclusively reveal why some residents experienced odors in their homes. However, the most likely scenario involves flow conditions that exceeded the normal operating range of the sewer system. As discussed above, this scenario could have been caused either by excessive sewer flow and/or a temporary blockage within the sewer system and is partially supported by the observance of residue on the ceiling of the sewer pipe along Michelle Street.

Table 1 - Monroe Township - Sewer Evaluation along Lani, Michelle and Lori Streets

Street Name	Pipe Run	Dia D (ft)	Flow Area (Half Full) A (sf)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Slope s (ft/ft)	Manning's Coefficient n	Half Full Pipe Capacity (cfs)	Half Full Pipe Capacity (gpm)	Residential Contribution to Sewer Segment				Remaining Capacity
										Number of Residences flowing into segment (homes)	Daily Flow per NJAC (1) (gpd)	Average Daily Flow (gpm)	Peak Diurnal Flow (2) (gpm)	Sewer Capacity Remaining available for the Landfill (gpm)
Lani	MH 1-2	0.67	0.17	1.05	0.17	0.005	0.013	0.4	194.9	1	800	0.6	1.2	193.7
	MH 2-3	0.67	0.17	1.05	0.17	0.016	0.013	0.8	337.3	17	13,600	9.4	20.9	316.3
	MH 3-4	0.67	0.17	1.05	0.17	0.004	0.013	0.4	174.8	21	16,800	11.7	25.9	148.9
Michelle	MH 4-5	0.67	0.17	1.05	0.17	0.039	0.013	1.2	528.9	29	23,200	16.1	35.7	493.2
	MH 5-6	0.67	0.17	1.05	0.17	0.013	0.013	0.7	304.6	33	26,400	18.3	40.7	264.0
	MH 6-7	0.67	0.17	1.05	0.17	0.005	0.013	0.4	183.9	36	28,800	20.0	44.4	139.6
Lori	MH 7-8	0.67	0.17	1.05	0.17	0.007	0.013	0.5	226.1	60	48,000	33.3	73.9	152.2

(1) Design Daily Flow per NJAC 7:9A-7.4(b) requires: 200 Gal - 1st Bedroom, 150 Gal per extra Bedroom = 800 gallons per day

(2) Diurnal Flow distribution taken from Table 2; Maximum 1/2 hour interval was reported at 4.62% of Total Daily Usage

Table 2 - Proposed Pumping Rates

Time of Day		Percent of Residential Daily Flow expected for each 1/2 hour period assuming Diurnal Flow	Grouping of Residential Usage Periods	Week 1 Baseline Pumping Rate (GPM)	Future Proposed Pumping Rate (GPM)
6:00	AM	2.0%	>2.0% - 3.0%	45	60
6:30		3.1%	>3.0%	45	45
7:00		3.8%		45	45
7:30		4.4%		45	45
8:00		4.6%		45	45
8:30		4.5%		45	45
9:00		4.1%		45	45
9:30		3.7%		45	45
10:00		3.3%		45	45
10:30		3.0%		45	45
11:00		2.7%	>2.0% - 3.0%	45	60
11:30		2.5%		45	60
12:00	PM	2.2%		45	60
12:30		2.0%		45	60
1:00		1.9%		45	60
1:30		1.9%		45	60
2:00		1.8%	0 - <2%	45	100
2:30		1.7%		45	100
3:00		1.7%		45	100
3:30		1.8%		45	100
4:00		2.0%	>2.0% - 3.0%	45	60
4:30		2.4%		45	60
5:00		2.7%		45	60
5:30		3.1%	>3.0%	45	45
6:00		3.5%		45	45
6:30		3.5%		45	45
7:00		3.4%		45	45
7:30		2.9%		45	45
8:00		2.6%	>2.0% - 3.0%	45	60
8:30		2.3%		45	60
9:00		2.1%		45	60
9:30		1.9%		45	60

Table 2 - Proposed Pumping Rates

Time of Day		Percent of Residential Daily Flow expected for each 1/2 hour period assuming Diurnal Flow	Grouping of Residential Usage Periods	Week 1 Baseline Pumping Rate (GPM)	Future Proposed Pumping Rate (GPM)
10:00		1.9%		45	60
10:30		1.6%		45	100
11:00		1.1%		45	100
11:30		0.8%		45	100
12:00		0.7%		45	100
0:30		0.5%		45	100
1:00		0.3%		45	100
1:30		0.3%		45	100
2:00		0.3%	0 - <2%	45	100
2:30		0.2%		45	100
3:00	AM	0.2%		45	100
3:30		0.3%		45	100
4:00		0.3%		45	100
4:30		0.4%		45	100
5:00		0.6%		45	100
5:30		1.0%		45	100
If Pumping occurred 24/7 (GPD):				64,800	102,900

Note: The Landfill is limited to 70,000 gpd calculated on a monthly basis